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Socio-Economic Conditions of Households Around Nag-Aso Lake, Philippines: Implications for Sustainable Resource Management

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Abstract

Nag-Aso Lake in Manito, Albay, Philippines, is a geothermal feature locally known for its steaming waters, yet the socio-economic realities of nearby communities remain poorly documented. This study examined the demographic and economic characteristics of households surrounding the lake, comparing resource user and non-user groups to guide sustainable resource management. A descriptive-comparative mixed-methods approach was employed, combining a census of 443 households, structured surveys, key informant interviews, and focus group discussions. Of these households, 307 provided complete income data for analysis. Results revealed that households consisted, on average, of four members, with a balanced gender ratio and primarily basic levels of educational attainment. Employment was concentrated in resource-based and semi-skilled work, particularly fishing, farming, and construction. Water-resource users experienced higher unemployment and greater reliance on informal activities, while fishers and coconut users showed relatively greater job stability. Although income and per capita earnings did not differ significantly between groups, most households reported food vulnerability and income insecurity. Housing ownership was common, yet over one-fourth relied on light or makeshift materials, heightening exposure to environmental risks. These findings underscore the economic vulnerability of geothermal communities despite their dependence on natural resources. Policies promoting livelihood diversification, education access, and sustainable resource management are vital to enhance resilience and ensure long-term socio-economic stability. This study provides the first empirical documentation of a geothermal lake community's socio-economic profile in the Philippines, providing essential insights for policy formulation and resource governance.

Keywords

Demographic profile; Nag-Aso lake; Resource users; Socio-economic conditions; Sustainable livelihoods

Introduction

Nag-Aso Lake is a three-hectare geothermal lake located in Manito, Albay, Philippines, locally known as "*Nag-Aso*", a Bicol term meaning "steaming" or "boiling". The lake's high-water temperature, ranging from 87°C to 96°C, results from sulfur oxide emissions from geothermal vents within the Pocdol volcanic mountain range. Its extreme thermal and chemical conditions make it distinct from typical freshwater lakes that support aquatic ecosystems and provide irrigation services. However, the same geothermal characteristics that make it a natural wonder also limit its direct use for fisheries or agriculture. Despite this ecological uniqueness, the socio-economic dynamics of households surrounding Nag-Aso Lake remain largely undocumented.

Manito, classified as a fourth-class municipality with a population of approximately 26,000, is mainly rural and resource-dependent. Many residents rely on employment linked to geothermal energy operations, farming, small-scale fishing, and forest-based livelihoods. For households living near Nag-Aso Lake, subsistence activities revolve around nearby rivers, coconut farming, and artisanal fisheries. While previous studies have examined geothermal lakes for their geochemical and volcanic properties (Di Napoli, Aiuppa and Allard, 2014; Fournier *et al*., 2009), and others have analyzed the socio-economic conditions of coastal and fishing communities in Bicol (Bigueja, Bigueja and Plantado, 2021; Labayo and Preña, 2024; Rivero *et al*., 2010), no studies to date have integrated geothermal ecological contexts with household livelihood systems in the Philippines.

Socio-economic factors such as family size, education, income, and housing conditions shape how households interact with and depend on natural resources. Education and access to skills development often strengthen livelihood resilience and promote sustainable resource use (Piao and Managi, 2023), whereas poverty and limited opportunities constrain adaptation options and increase vulnerability (Vadivel *et al*., 2023). Distinguishing between resource-user and non-user households (those directly engaging in resource extraction or use) and non-users provides an opportunity to better understand livelihood strategies, vulnerability levels, and long-term socio-economic development potential in geothermal-dependent communities.

This study also contributes to the global sustainable development discourse by aligning with the United Nations Sustainable Development Goals (SDGs), particularly SDG 1 (No Poverty), SDG 8 (Decent Work and Economic Growth), and SDG 13 (Climate Action). By examining the socio-economic realities of households surrounding Nag-Aso Lake, the study highlights the interface between local livelihood practices and environmental sustainability. Evidence generated can support national and regional development planning, particularly in strengthening climate-resilient and inclusive rural economies in geothermal areas.

This study aims to describe the demographic and economic conditions of households surrounding Nag-Aso Lake and to compare resource users with non-users. Through this analysis, the study seeks to contribute to the understanding of how natural resource dependency influences household welfare and to generate empirical evidence to inform

local development policies and strategies for sustainable resource management in geothermal environments.

Conceptual Framework

This study is grounded in the premise that household socio-economic characteristics directly influence how families' access and utilize natural resources, and in turn, resource utilization shapes livelihoods, income levels, housing conditions, and overall resilience. In geothermal communities such as those surrounding Nag-Aso Lake, the balance between human needs and natural resource sustainability is particularly fragile in geothermal environments.

The framework follows the Sustainable Livelihoods Approach (SLA) (Chambers and Conway, 1992; DFID, 1999). The SLA highlights five types of assets that households draw upon: human, natural, financial, physical, and social. Households mobilize these assets to secure livelihoods and well-being, but vulnerability arises when one or more assets are constrained. For communities near Nag-Aso Lake, natural resources such as water, fish, and coconuts form the backbone of household survival. However, limited human capital (education, skills) and weak financial resources constrain their ability to adapt to economic shocks or environmental hazards.

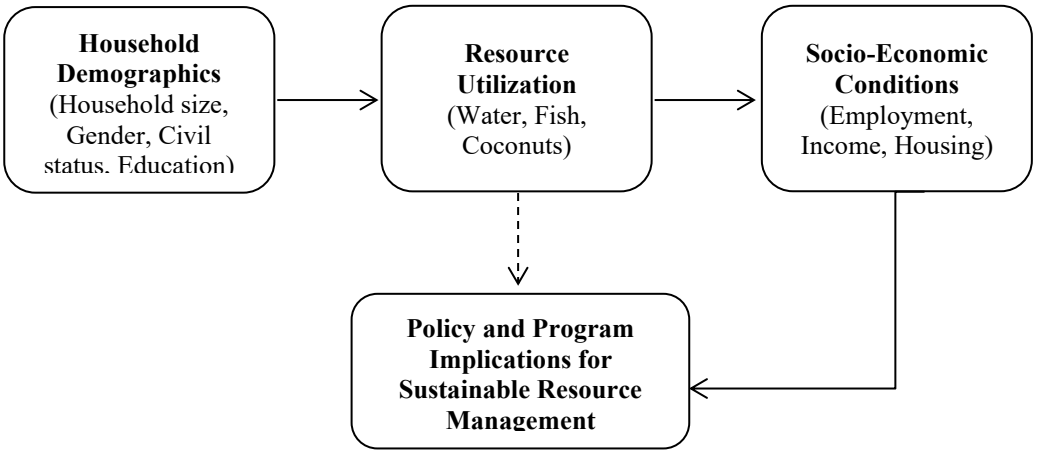

Figure 1: Conceptual Paradigm of the Study

As shown in figure 1, household demographics (e.g., size, gender distribution, civil status, and educational attainment) affect the capacity to access and manage resources. Patterns of resource utilization (water for domestic and agricultural use, fish for livelihoods, and coconuts for farming and trade) are critical pathways influencing socio-economic outcomes such as employment, income, and housing conditions. These outcomes, in turn, determine the resilience or vulnerability of households in geothermal environments.

By articulating these relationships, the study positions socio-economic analysis not only as a descriptive exercise but also as a tool for informing policies and programs that promote sustainable resource management. Such an integrated perspective is necessary for strengthening the resilience of households in geothermal communities. This conceptual

model guided both data collection and analysis, allowing a holistic understanding of the interrelationships between socio-economic variables and resource dependency.

Methodology

Research Design

The study used a descriptive-comparative design to examine differences between households that use natural resources and those that do not. A mixed-methods approach was adopted, integrating both quantitative and qualitative techniques to strengthen data validity and provide comprehensive insights. Quantitative data were collected through structured household surveys to assess demographic characteristics, income, livelihood sources, and resource-use practices. Qualitative data were gathered through key informant interviews (KIIs) and focus group discussions (FGDs) to explore community perceptions, cultural practices, livelihood challenges, and adaptive strategies. Methodological triangulation enhanced the robustness, credibility, and depth of the findings.

Study Area and Respondents

The research was conducted in Barangays Holugan and Balabagon, located in Manito, Albay, Philippines (Figure 2), directly adjacent to Nag-Aso Lake. These barangays were purposively selected due to their proximity to the geothermal lake and dependence on surrounding natural resources for livelihood.

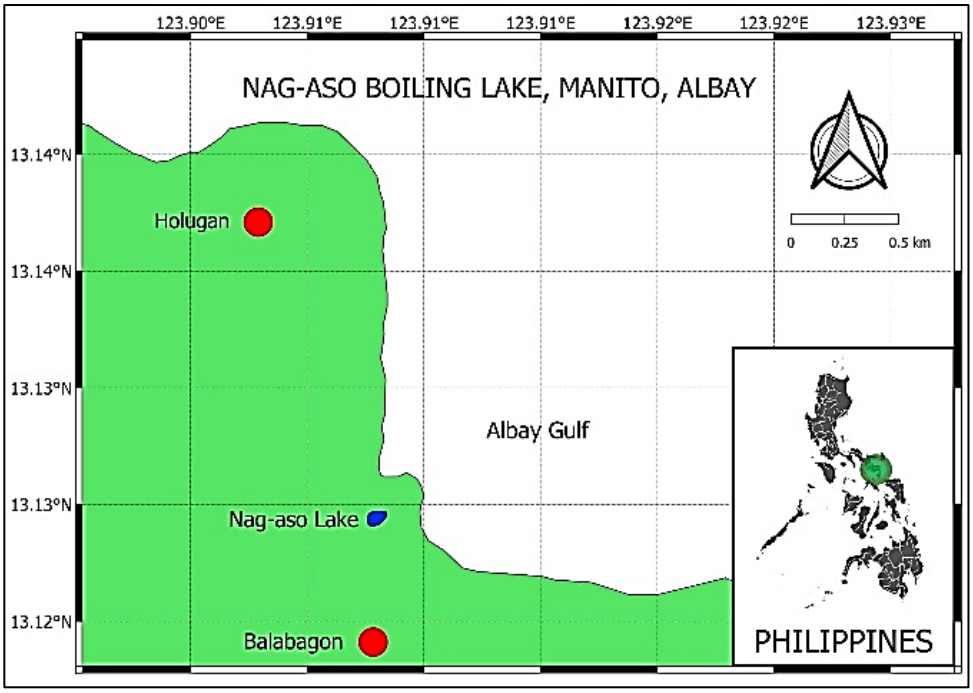

Figure 2: Geographic location of Nag-Aso Boiling Lake and Surrounding Study Communities

A total of 443 households were identified during the community census, and a complete enumeration was conducted. Full coverage was chosen because the population size was sufficiently small to allow for complete household listing, and field access was highly feasible with the support of barangay officials. This approach ensured more accurate community-wide estimates and eliminated sampling error. Of the 443 households, 307 voluntarily disclosed their monthly household income and were included in the final socio-economic analysis, while the rest contributed demographic and qualitative information.

Data Collection Procedures

Seven trained enumerators administered structured questionnaires using the Kobo Toolbox digital survey platform. Orientation sessions were conducted before fieldwork to ensure accuracy, consistency, and adherence to ethical standards. Informed consent and confidentiality protocols were strictly observed.

Field data collection was supervised by a project coordinator with support from barangay leaders. In addition to surveys, a total of six KIIs were conducted with local government representatives, barangay officials, long-term residents, and community leaders who possessed historical knowledge about resource conditions to provide contextual and policy-relevant insights. Likewise, three FGDs were held (one each with fishers, coconut farmers, and water resource users), consisting of 8–10 participants per group, selected through purposive sampling based on their direct involvement in livelihood activities to capture community perspectives on resource use, livelihood challenges, and coping strategies. These qualitative methods enriched the interpretation of household-level data.

Data Analysis

Quantitative results were analyzed using descriptive statistics such as frequencies, medians, and percentages to profile household demographics, employment, income, and housing conditions. Group comparisons between resource users and non-users were performed using the Mann-Whitney U test, appropriate for non-parametric distributions. All statistical analyses were conducted using JAMOVI software version 2.6.19 (The Jamovi Project, 2024). For each comparison, effect sizes (rank-biserial correlation, r) were computed to indicate the magnitude of differences, and 95% confidence intervals for median values were estimated to improve interpretability. Effect sizes were interpreted using Cohen's conventions (small = 0.10, medium = 0.30, large = 0.50).

Because multiple comparisons were conducted across several socio-economic indicators and three resource categories, all statistical tests were evaluated at the 0.05 significance level, and no p-value adjustments (e.g., Bonferroni or FDR) were applied. This approach is appropriate for exploratory socio-economic profiling, but results should be interpreted with awareness of the increased risk of Type I error.

Qualitative data from KIIs and FGDs were analyzed thematically. Responses were coded into categories such as employment, resource dependency, and livelihood challenges, which were then used to contextualize and validate quantitative results.

Ethical Considerations

All participants provided informed consent before participation. Confidentiality and voluntary participation were observed throughout the study. Ethical clearance was obtained from the Sorsogon State University Research Ethics Committee, ensuring compliance with institutional and national guidelines on human research.

Limitations

A limitation of this study is that 136 households (30.7%) did not disclose income, reducing the analytic sample to 307 households. To assess potential non-response bias, households that reported and those that did not were compared across observable characteristics (Appendix A1). Significant differences were found in household size, number of dependents, and unemployment, with non-reporting households exhibiting smaller household sizes, fewer dependents, and higher unemployment. Chi-square tests also showed that non-reporters were less likely to be users of water and fish resources. No significant differences were found for housing materials, floor area, or coconut resource use.

These patterns suggest that income non-disclosure is associated with slightly higher vulnerability and lower participation in resource-based livelihoods. As a result, income-related findings may underrepresent the most economically insecure households. While disclosure rates were high enough to support robust analysis, income-related results should be interpreted with caution.

Results

Demographic Profile of Households

A total of 307 households surrounding Nag-Aso Lake were analyzed. Table 1 presents the descriptive statistics of household demographics.

Table 1: Demographic Profile of Households Surrounding Nag-Aso Lake (n = 307)

Household Demographics	Median	Mode	Sum	Min	Max
Household size	4	4	1,260	1	11
Gender Distribution					
○ No. of Male	2	2	654	0	6
○ No. of Female	2	1	606	0	7
Civil Status					
○ No. of Single Members	3	2	840	0	9
○ No. of Married Members	2	2	376	0	3
○ No. of Widowed/ Separated	0	0	44	0	2
Educational Attainment					
○ No formal education	0	0	178	0	4
○ Basic Education	2	2	854	0	9
○ Vocational Training	0	0	45	0	2
○ College/Advanced degree	0	0	183	0	5

The median household size (Figure 3) was four members, similar to the national average per household reported by the Philippine Statistics Authority (Mapa, 2022). As shown also in Figure 3, households generally consisted of two males and two females, reflecting a balanced gender distribution. This demographic pattern aligns with national sex ratio trends (Mapa, 2022) and is often associated with equitable decision-making and labor participation in resource-dependent communities (Doss, 2013; Kabeer and Natali, 2013).

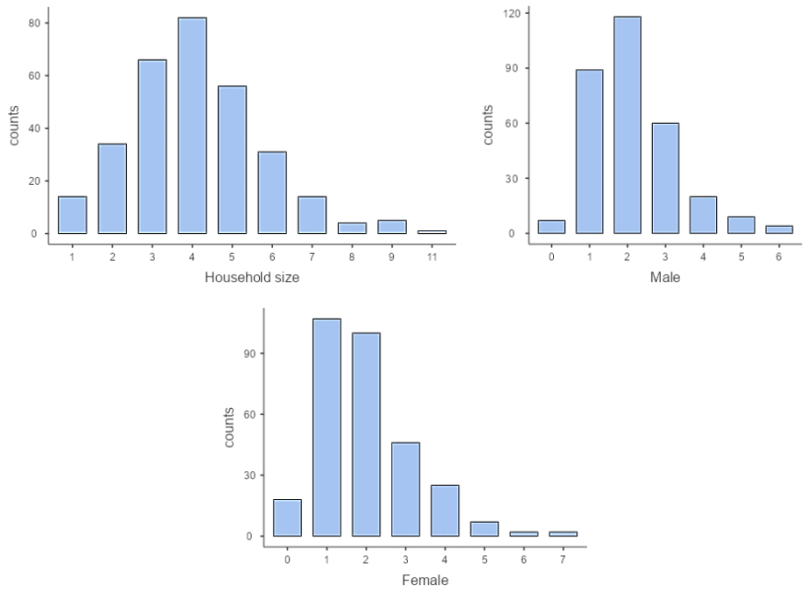

Figure 3: Household size and gender composition of households surrounding Nag-Aso Lake (n=307)

Civil status data (Figure 4) indicated that most households were composed of two married members, underscoring the prevalence of nuclear family structures in the area. This pattern points to the findings of Medina (2015), who emphasized the stability of nuclear families in rural Philippines, and with Giddens *et al*. (2021), who noted their importance for child welfare and intergenerational support. Widowed or separated members were rare across households, suggesting stable household structures.

Educational attainment results (Figure 5) revealed that the majority of household members had completed only basic education, while very few attained vocational or college-level training. This reflects structural barriers to higher education in rural areas, such as financial constraints and geographic inaccessibility (Albert, Dumagan and Martinez, 2015). Lower educational attainment may constrain livelihood diversification, income potential, and adoption of sustainable resource management practices (Psacharopoulos and Patrinos, 2018; Piao and Managi, 2023).

Resources in Lakeside Communities

The resource map of Barangays Hulogan and Balabagon, located near Nag-Aso Lake, illustrates the natural and community resources available to households (Figure 6). The

most abundant resources include spring water, fish, and coconut, which serve as the primary sources of livelihood and household sustenance.

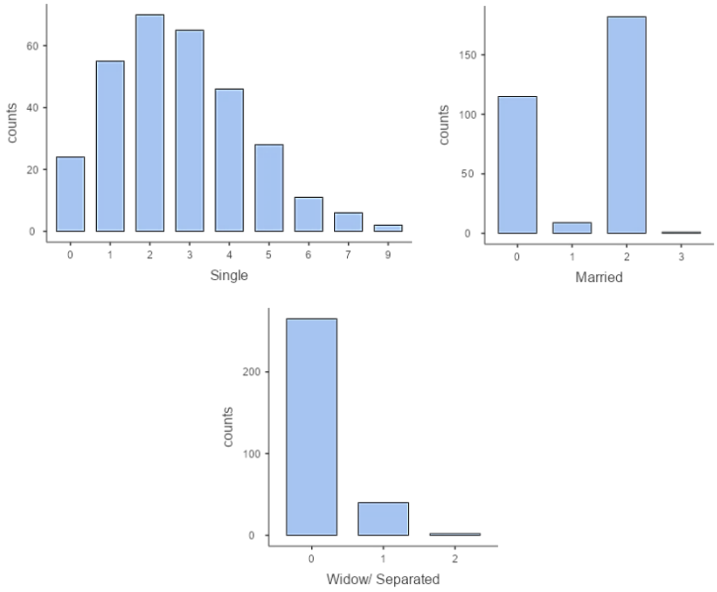

Figure 4: Civil status of Households Surrounding Nag-Aso Lake (n=307)

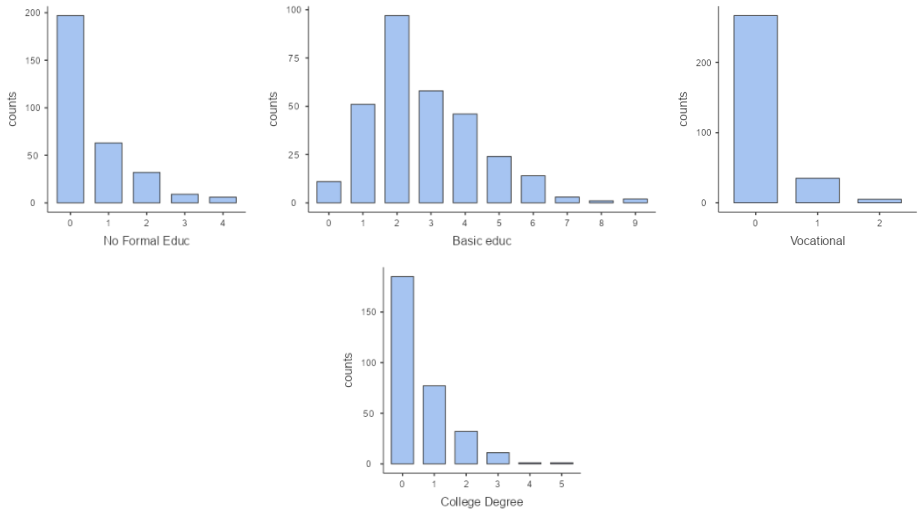

Figure 5: Educational Attainment of Households Surrounding Nag-Aso Lake (n=307)

For analytical classification, households were grouped according to clear and consistent usage criteria. Water-resource users were defined as households that collected spring water at least three times per week for drinking, cooking, or domestic needs. Fish-resource users were individuals who engaged in fishing, gleaning, or fish vending at least once a week, whether for their livelihood or regular consumption. Coconut-resource users were households cultivating, harvesting, or selling coconuts at least once per month, consistent with the crop's longer production cycle. These categories were not

mutually exclusive, acknowledging that many households rely on multiple resources simultaneously as part of their livelihood strategy.

Quantitatively, resource dependence is widespread. Out of 443 households, 153 households (35%) were classified as water-resource users, 326 households (74%) as fish-resource users, and 156 households (35%) as coconut-resource users. These figures indicate that fishing is the dominant livelihood-linked resource, followed by water collection and coconut farming. The substantial overlap across categories supports qualitative accounts describing multifunctional livelihood strategies among households.

Spring water remains essential for daily domestic use, especially for households without access to piped water systems. Fish resources along the Albay Gulf support small-scale fisheries and household consumption, providing steady, though often variable, employment to fishers, gleaners, and vendors. Coconut trees are similarly abundant and form the basis for copra production and small-scale trading. Although earnings from coconut farming are modest, the activity offers predictable income during harvest cycles and serves as a financial buffer in times of need.

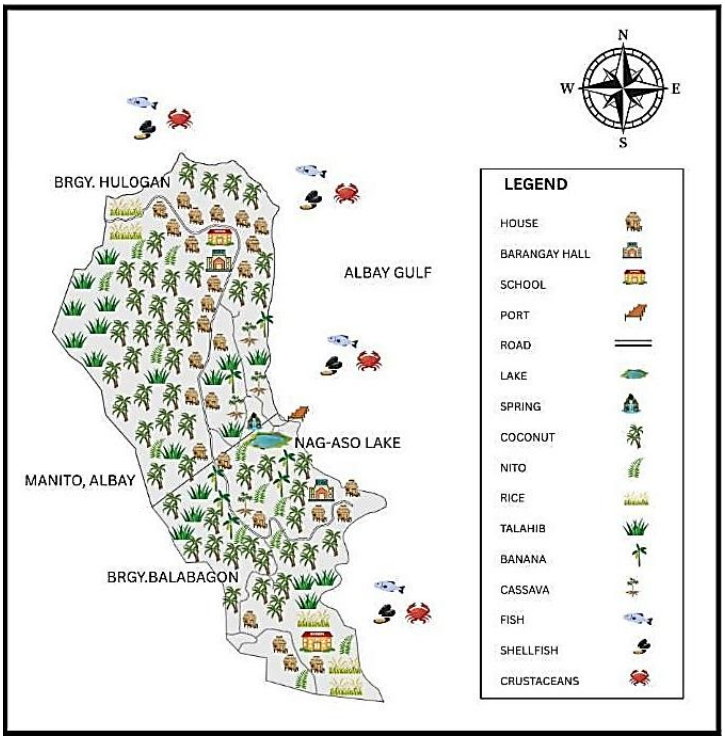

Figure 6: Resource map of Nag-aso lakeside community

Other resources visible in the area include rice fields, banana groves, cassava plots, and secondary vegetation such as *talahib*[1] and *nito*[2], which are used in handicrafts. These

[1] A tall wild grass (*Saccharum spontaneum*) used for fodder and roofing materials.
[2] A climbing fern (*Lygodium circinnatum*) used for weaving baskets and handicrafts.

supplementary resources diversify subsistence and income options, though they are less dominant compared to water, fish, and coconuts.

Overall, households near Nag-Aso Lake depend heavily on these natural assets for subsistence and income, underscoring the need to link demographic characteristics with resource utilization for sustainable management and economic stability.

Demographic Profiles of Resource Users and Non-Users

When comparing resource users and non-users, Table 2 shows that the median household size was four across all groups, with similar gender distributions and civil status patterns. Both users and non-users reported two married members on average and three single members. Educational attainment also did not differ significantly, as most households across groups reported basic education as the highest level achieved. These similarities suggest that demographic characteristics may not be the primary determinant of resource utilization. Instead, economic opportunities and environmental access may play a stronger role, a finding consistent with Quisumbing, Estudillo and Otsuka (2003), who observed that household size and structure shape resource allocation but are not always predictive of utilization patterns.

Table 2: Demographic Profile of Resource Users and Non-Users Around Nag-Aso Lake (n = 307)

Household Demographics	*Water Resources*		*Fish*		*Coconut*	
	Users (n=120)	*Non-Users (n=187)*	*Users (n=243)*	*Non-Users (n=64)*	*Users (n=106)*	*Non-Users (n=201)*
Household size	4	4	4	4	4	4
Gender Distribution						
○ Male	2	2	2	2	2	2
○ Female	2	2	2	2	2	2
Civil Status						
○ Single	3	2	3	2	3	3
○ Married	2	2	2	2	2	2
○ Widowed/ Separated	0	0	0	0	0	0
Educational Attainment						
○ No formal education	0	0	0	0	0	0
○ Basic Education	3	2	2	3	3	2
○ Vocational Training	0	0	0	0	0	0
○ College or Postgraduate degree	0	0	0	0	0	0

Economic Conditions of Households

The economic profile of households indicated a strong dependence on resource-based and manual occupations. As shown in table 3, a total of 203 economically active household heads were included in the occupational classification. This figure is lower than the total number of surveyed households (307) because 104 household heads were not participating in the labor force at the time of the survey. These excluded individuals were either retired, unemployed but not actively seeking work, disabled, or engaged full-

time in caregiving or domestic responsibilities, and were therefore omitted to accurately represent the working segment of the population.

Table 3: Occupational Distribution of Economically Active Household Heads Surrounding Nag-Aso Lake (n = 203)

Occupational Category	*Specific Occupations*	*Freq*	*%*
Skilled and Semi-skilled	Construction worker, driver, carpenter, welder, technician, operator, electrician, plumber, steelman	80	39.40%
Resource-based	Fisher, farmer, copra worker, *Bantay Dagat*	66	32.50%
Service	Laborer, helper, housekeeper, security guard, utility worker, cook, rider	29	14.30%
Government and Community	Barangay official, *tanod*, child development worker, tax mapper	8	3.90%
Professional	Teacher, safety officer, seaman	5	2.50%
Entrepreneurial	Vendor, businessman	11	5.40%
Industrial	Factory worker	4	2.00%
TOTAL		203	100.00%

Note: Of the 307 surveyed households, only 203 household heads were economically active. A total of 104 household heads were excluded because they reported no livelihood activity (e.g., retired, unemployed, disabled, full-time caregivers, or otherwise outside the labor force).

Among the economically active respondents, 39.4% were engaged in skilled and semi-skilled work such as construction, carpentry, welding, and driving. Resource-based occupations, including fishing, farming, copra production, and *Bantay Dagat*[3] Work accounted for 32.5% of the active labor force. Service workers accounted for 14.3%, while smaller proportions were employed in government/community roles (3.9%), professional occupations (2.5%), entrepreneurial work (5.4%), and industrial employment (2.0%). This occupational structure aligns with previous findings by Barbier and Hochard (2019) and Cinner *et al*. (2018), who observed that rural households in developing regions continue to rely heavily on natural resources and manual labor, contributing to vulnerability to market and environmental fluctuations.

Household income distributions are illustrated in Figure 7. Most households earn below ₱20,000 per month, with the largest cluster reporting incomes below ₱10,000. Per capita income followed a similar pattern, with most households reporting less than ₱5,000 per member. These results demonstrate widespread income insecurity, consistent with global evidence that rural households often rely on diversified but low-yield livelihoods (Davis, Di Giuseppe and Zezza, 2014; Dercon, 2002).

[3] A community-based volunteer sea patrol group in the Philippines tasked with monitoring coastal areas, preventing illegal fishing, and supporting marine conservation efforts.

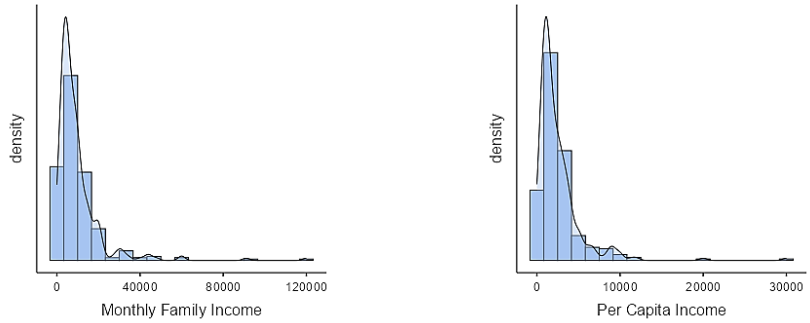

Figure 7: Income of Households Surrounding Nag-Aso Lake (n=307)

Housing conditions further illustrated both stability and vulnerability. As shown in Table 4, 81.2% of households own their homes, either as house-and-lot properties (45%) or as houses built on family land with consent (36.2%). However, Table 5 indicates that 26.4% of households lived in dwellings constructed from light or makeshift materials, making them highly susceptible to natural hazards. These findings echo global studies that emphasize the importance of durable housing in reducing disaster risk (UN-Habitat, 2020; World Bank, 2015).

Table 4: Housing Ownership of Households Surrounding Nag-Aso Lake (n=307)

Housing Ownership	*Freq*	*%*
Owned (house & lot)	138	45.00%
Own a house on a free lot with the consent of the owner	111	36.20%
Own a house on a rented lot	38	12.40%
Borrowed/shared with the owner	12	3.90%
Rented house/room	5	1.60%
Own a house on a free lot without the consent of the owner	1	0.30%
Living in a public space without rent	1	0.30%
Other	1	0.30%
TOTAL	307	100.00%

Table 5: Housing Materials and Type of Dwelling of Households Surrounding Nag-Aso Lake (n=307)

Housing materials	*Type of Dwelling*		*Total*	*%*
	Single	*Duplex*		
Mixed but predominantly strong materials	108	5	113	36.80%
Strong materials (galvanized iron, aluminum, tile, concrete, brick, stone, asbestos)	92	18	110	35.80%
Light materials (*cogon, nipa, anahaw*)	41	1	42	13.70%
Mixed but predominantly light materials	39	0	39	12.70%
Salvaged/makeshift materials	3	0	3	1.00%
TOTAL	283	24	307	100.00%

Self-assessed economic conditions are illustrated in figure 8. The majority of households (n = 223) considered themselves “on the line,” while 78 described themselves as “poor” and only six as “not poor.” Nearly one-third reported recent experiences of hunger,

reflecting food insecurity. As summarized in Table 6, those who identified as "not poor" reported higher incomes and more full-time employment, while "poor" and "on the line" households relied heavily on irregular or informal work. These findings are consistent with FAO (2021), which stressed that food insecurity remains a key marker of rural vulnerability.

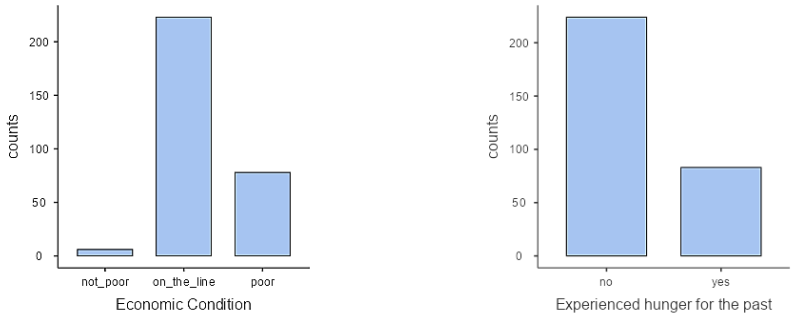

Figure 8: Self-Assessed Economic Condition and Food Security of Households Surrounding Nag-Aso Lake (n=307)

Table 6: Relationship Between the Socio-economic Profile and the Self-Assessed Economic Condition of Households Surrounding Nag-Aso Lake (n=307)

Socio-economic Indicators	*Poor (n=78)*			*On the Line (n=223)*			*Not Poor (n=6)*		
	Med	*Min*	*Max*	*Med*	*Min*	*Max*	*Med*	*Min*	*Max*
No. of Dependents	2	0	6	2	0	9	2	1	3
Unemployed	0	0	2	0	0	4	1	0	5
Self-employed	0	0	2	0	0	6	0.5	0	1
Informal workers (Part-time)	0	0	3	0	0	2	0	0	2
Employed (Full-time)	1	0	2	1	0	4	1	0	5
Monthly Family Income (₱)	5,000	1,000	30,000	7,000	25	120,000	12,000	4,000	91,000
Per Capita Income (₱)	1,500	250	10,000	1,833	6	30,000	1,792	1,000	11,375

Resource Users vs. Non-Users

The comparisons of socio-economic outcomes between users and non-users are shown in tables 7 – 9.

Water resource users reported significantly higher unemployment and greater reliance on self-employment than non-users (U = 9,121, p = 0.002), with small effect sizes (r = 0.19–0.17), indicating modest but meaningful differences between groups (Table 7). Non-users, by contrast, showed higher full-time employment (U = 9,569, p = 0.016; r = –0.15), suggesting greater livelihood stability among households not dependent on water resources.

Qualitative findings reinforced these patterns. One water user shared, *"When there is no other work, we depend on collecting water, but it is not enough to earn a living",* directly reflecting the higher unemployment rate observed quantitatively. Physical strain was another recurring theme: *"We depend on the spring every day, but the walk gets harder during bad weather",* illustrating vulnerability despite consistent access to resources.

Table 7: Economic Characteristics of Water Resource Household (HH) Users and Non-Users Surrounding Nag-Aso Lake (n = 307)

Water Resources	*Users (n=120)*			*Non-Users (n=187)*			*U statistic*	*p-value*	*Effect size (r)*
	Med	*Min*	*Max*	*Med*	*Min*	*Max*			
No. of Dependents	2	0	7	2	0	9	10,709	0.492	N/A
Unemployed	1	0	5	0	0	4	9,121	0.002	0.18712
Self-employed	0	0	6	0	0	2	9,278	0.001	0.17308
Informal workers	0	0	3	0	0	2	11,166	0.928	N/A
Employed	0	0	4	1	0	5	9,569	0.016	-0.14715
Monthly Family Income (₱)	8,000	25	120,000	6,000	27	91,000	10,110	0.143	N/A
Per Capita Income (₱)	2,000	6	20,000	1,631	7	30,000	10,990	0.762	N/A
Floor area (sq. m.)	30	1	400	24	6	400	9,720	0.048	0.13373

Despite these challenges, water users reported larger housing floor areas (30 sq. m. versus 24 sq. m.; U = 9,720, p = 0.048; r = 0.13), indicating modest differences in physical capital. This suggests that even irregular income streams may be periodically invested in housing. These results align with observations by IFAD (2016) and Barbier and Hochard (2019), who have linked resource dependence to unstable livelihoods and limited diversification.

Table 8: Economic Characteristics of Fish Resource Household (HH) Users and Non-Users Surrounding Nag-Aso Lake (n = 307)

Fish Resources	*Users (n=243)*			*Non-Users (n=64)*			*U statistic*	*p-value*	*Effect size (r)*
	Med	*Min*	*Max*	*Med*	*Min*	*Max*			
No. of Dependents	2	0	9	2	0	5	6,329	0.019	0.1861
Unemployed	0	0	4	1	0	5	5,039	<.001	-0.352
Self-employed	0	0	3	0	0	6	7,687	0.86	N/A
Informal workers	0	0	3	0	0	1	7,496	0.568	N/A
Employed	1	0	5	1	0	4	7,657	0.835	N/A
Monthly Family Income (₱)	7,000	320	120,000	6,000	25	60,000	6,966	0.199	N/A
Per Capita Income (₱)	1,833	107	30,000	1,450	6	10,000	6,785	0.116	N/A
Floor area (sq. m.)	28	1	400	29	6	360	7,355	0.505	N/A

Among fish resource users, unemployment was significantly lower compared to non-users (U = 5,039, p < 0.001), with a small-to-medium effect size (r = –0.35), indicating that fishing offered more stable occupational engagement than alternative livelihoods (Table 8). This was echoed in FGDs where a fisher explained, *"Even when income is low, at least the sea gives us work every day".*

However, no significant differences were found in income (U = 6,966, p = 0.199) or housing floor area (U = 7,355, p = 0.505), with effect sizes near zero, suggesting negligible practical differences between users and non-users. Participants frequently described experiencing fluctuating income despite holding regular employment. As one remarked, *"Sometimes the catch is good, sometimes it's almost nothing",* capturing the volatility typical of marine-based livelihoods.

These findings are consistent with FAO (2020), which reported that fishing often sustains households through regular employment but does not necessarily lead to higher or more stable earnings due to environmental fluctuations and market uncertainty.

Table 9: Economic Characteristics of Coconut Resource Household (HH) Users and Non-Users Surrounding Nag-Aso Lake (n = 307)

Coconut Resources	*Users (n=106)*			*Non-Users (n=201)*			*U statistic*	*p-value*	*Effect size (r)*
	Med	*Min*	*Max*	*Med*	*Min*	*Max*			
No. of Dependents	2	0	7	2	0	9	10,130	0.471	N/A
Unemployed	0	0	5	1	0	4	9,295	0.04	-0.12748
Self-employed	0	0	6	0	0	2	10,551	0.863	N/A
Informal workers	0	0	3	0	0	2	9,601	0.066	N/A
Employed	1	0	2	1	0	5	10,053	0.368	N/A
Monthly Family Income (₱)	7,500	27	120,000	6,000	25	91,000	9,868	0.288	N/A
Per Capita Income (₱)	2,000	7	30,000	1,667	6	11,987	9,852	0.278	N/A
Floor area (sq. m.)	35	6	400	24	1	400	8,062	<.001	0.24322

Coconut resource users exhibited lower unemployment than non-users ($U = 9,295$, $p = 0.040$; $r = –0.13$), indicating small but consistent effects of coconut farming on employment stability (Table 9). Income and per capita earnings showed no significant differences ($p > 0.05$), with negligible effect sizes, although users reported slightly larger housing floor areas ($U = 8,062$, $p < 0.001$; $r = 0.24$), reflecting a moderate effect and suggesting greater investment in physical capital among coconut-based households.

FGD narratives reinforced these observations. A farmer explained, *"The harvest only comes every few months, but it is steady. We can always count on it",* illustrating predictable, though infrequent, income. Another added, *"We stretch what little we have between harvests",* highlighting the need for careful budgeting in coconut-dependent households.

These findings mirror the ADB (2022), which identified coconut production as a relatively stable but low-profit livelihood common in rural economies.

Discussion

Overall, the findings demonstrate that while demographic characteristics are broadly similar across user and non-user groups, economic conditions reveal nuanced differences shaped by resource dependency. Water users faced higher unemployment, fish users enjoyed more stable employment but without income gains, and coconut users benefited from modest employment stability. These findings confirm that resource dependency in geothermal communities' shapes household resilience in complex ways, echoing global evidence that natural resource reliance does not uniformly translate into economic security (Cinner *et al*., 2018; World Bank, 2015).

The demographic structure of households near Nag-Aso Lake mirrors patterns seen in rural communities across the Philippines. Most families are small to medium-sized and

are usually organized as nuclear households. This pattern is consistent with national data (Mapa, 2022) and has been linked with household stability in rural areas (Medina, 2015).

However, Educational attainment emerged as a key constraint. The majority of household members attained only a basic education, with very few completing vocational or tertiary training. This reflects the common barriers faced by rural communities, such as distance to schools, high costs, and lack of facilities (Albert, Dumagan and Martinez, 2015). Education is important not only for personal opportunities but also for household resilience, as those with higher levels of schooling are better able to diversify income and adopt sustainable practices (Piao and Managi, 2023).

Livelihoods in the area depend heavily on fishing, farming, and semi-skilled jobs. While these provide a basic income, they are often seasonal and unstable. This pattern mirrors other rural settings where families rely on natural resources, leaving them vulnerable to market shifts and environmental risks (Cinner *et al*., 2018; Barbier and Hochard, 2019). The low-income levels found in this study are also consistent with earlier findings that rural households in Asia and Africa often fall below poverty thresholds (Davis, Di Giuseppe and Zezza, 2014; Dercon, 2002).

Although most households' own homes, housing quality is a concern, with over one-quarter residing in structures made from light or temporary materials. This increases exposure to climate-induced hazards such as typhoons and flooding—risks that are particularly pronounced in the Bicol Region. These findings echo global assessments on housing vulnerability among low-income communities facing frequent natural hazards (UN-Habitat, 2020; World Bank, 2015).

Comparisons between resource users and non-users highlight the diverse pathways households employ to sustain livelihoods. Water-dependent households experienced higher unemployment, suggesting that reliance on spring resources alone did not provide a stable income; yet, some investments in housing indicate intermittent income opportunities. Fishing households demonstrated lower unemployment but limited income growth, reinforcing the notion that small-scale fisheries, while essential to rural employment, often struggle to provide upward mobility (FAO, 2020). Coconut-based livelihoods provided relatively steady yet modest earnings, consistent with the characterization of coconut farming as a resilience-oriented but low-return strategy in rural Southeast Asia (ADB, 2022).

A critical dimension distinguishing Nag-Aso Lake from other rural contexts is its geothermal nature. The lake's extreme temperatures (87–96°C) and sulfur-rich composition render it unsuitable for direct use in domestic, agricultural, or aquaculture applications. Community reliance on surrounding cold springs, rather than the lake itself, demonstrates adaptive behavior in an environment where the primary natural feature is not directly utilizable. However, using spring water adjacent to a geothermal system may still pose contamination and health risks, including possible exposure to sulfur compounds and geothermal by-products during rainy seasons when water pathways shift. Although no formal testing was conducted in this study, community members in KIIs expressed concerns about water discoloration during heavy rains and occasional sulfur odor, indicating perceived environmental risk.

These circumstances highlight gaps in water safety monitoring, as barangay officials reported no routine testing for potability. The absence of systematic regulation is not unique to Manito but reflects broader challenges in managing water resources in rural geothermal zones. Because geothermal activity also shapes land stability, households located near fissures and altered terrain face environmental hazards that have not yet been formally assessed by local agencies.

Overall, the findings underscore a paradox common in resource-reliant rural settings: natural resources provide subsistence and stability, yet they seldom enable transformative socio-economic progress. In the case of Nag-Aso Lake, households exhibit resilience through diversified subsistence strategies but remain vulnerable due to limited education, volatile income sources, and exposure to environmental hazards. This study contributes to the sustainable livelihoods literature by demonstrating how geothermal ecologies influence livelihood decision-making and vulnerability, emphasizing the need for integrated policies that strengthen human capital, promote livelihood diversification, and enhance climate-resilient infrastructure.

Conclusion

This study provides a comprehensive assessment of the socio-economic characteristics of households surrounding Nag-Aso Lake, a geothermal ecosystem in Manito, Albay, Philippines. The findings revealed that family size, income level, education, and housing conditions play a decisive role in shaping livelihood strategies and household dependence on natural resources. Resource-user households tend to rely more heavily on natural and physical capital, while non-users diversify income through off-farm employment and services, indicating distinct adaptive capacities within the community.

Sustainable management of geothermal resource environments requires a people-centered approach that strengthens human capital through education and training, expands access to credit and markets, and improves housing and infrastructure. Integrating local government and academic institutions can further bridge knowledge gaps and sustain development interventions. In broader terms, this research contributes to the advancement of SDG 1 (No Poverty), SDG 8 (Decent Work and Economic Growth), and SDG 13 (Climate Action) by providing empirical evidence on how socio-economic factors influence livelihood sustainability in geothermal lake communities.

Recommendations

Based on the findings, the following strategies are recommended to enhance household resilience and promote sustainable resource management in communities surrounding Nag-Aso Lake:

1) Promote livelihood diversification through local cooperatives.
   The Municipal Government of Manito, in partnership with the Department of Trade and Industry (DTI) and the Department of Labor and Employment (DOLE), should support the creation of producer cooperatives among coconut farmers and fishers. These cooperatives may engage in value-adding enterprises such as coconut sugar processing or dried fish production to generate higher and more stable incomes.

2) Integrate vocational and technical skills development.
Collaboration with the Technical Education and Skills Development Authority (TESDA) and the Department of Education (DepEd) should expand training for youth and underemployed adults in Balabagon and Hulogan. Courses in carpentry, food processing, and bookkeeping can better equip residents with employable skills beyond resource extraction.

3) Enhance access to safe and climate-resilient housing.
The Municipal Government of Manito, in coordination with the National Housing Authority (NHA) and the Department of Social Welfare and Development (DSWD), should promote affordable housing materials and hazard-resilient designs suitable for areas prone to typhoons and landslides.

4) Strengthen environmental stewardship and resource governance.
Local barangay councils, with guidance from the Department of Environment and Natural Resources (DENR) and Sorsogon State University (SorSU) through *Project DANAO*, should formulate community-based guidelines for sustainable water use and reforestation to reduce soil erosion and maintain lake water quality.

5) Institutionalize regular socio-economic and environmental monitoring.
Sorsogon State University (SorSU), in partnership with the Municipal Government of Manito, should conduct regular household profiling and resource-use assessments to track the effectiveness of interventions and measure community progress over time.

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Appendix A1: Comparison of Reporting and Non-reporting Households on Key Observable Characteristics

A. Continuous and Ordinal Variables (Mann–Whitney U Test)

Variable	*Median*		*U statistic*	*p-value*	*Effect Size (r)*
	Reporters (n = 307)	*Non-reporters (n = 136)*			
Household size	4	3	11,714	<0.001	0.4389
Number of dependents	2	1	16,014	<0.001	0.2329
Unemployed	0	1	13,239	<0.001	–0.3659
Floor area (sq. m.)	28	25	20,422	0.714	N/A

B. Categorical Variables (Chi-square Test)

Variable	*Frequency / Percentage*		*χ^2 statistic*	*p-value*	*Cramer's V*
	Reporters (n = 307)	*Non-reporters (n = 136)*			
Housing (light/salvaged materials)	45 (15%)	28 (21%)	2.408	0.121	0.074
Water resource users	120 (39%)	33 (24%)	9.16	0.002	0.144
Fish resource users	243 (79%)	83 (61%)	15.90	<0.001	0.190
Coconut resource users	106 (35%)	50 (37%)	0.207	0.649	0.0216

Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*
Conceived and designed the research or analysis	Yes	No
Collected the data	Yes	Yes
Contributed to data analysis & interpretation	Yes	Yes
Wrote the article/paper	No	Yes
Critical revision of the article/paper	Yes	Yes
Editing of the article/paper	No	Yes
Supervision	Yes	No
Project Administration	Yes	No
Funding Acquisition	Yes	No
Overall Contribution Proportion (%)	60	40

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Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind animal. The contexts of animals were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of ARRIVE does not apply in cases of this study or written work.

Research on Indigenous Peoples and/or Traditional Knowledge
The author(s) solemnly declare(s) that this research has not involved Indigenous Peoples as participants or respondents. The contexts of Indigenous Peoples or Indigenous Knowledge were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or prior informed consent (PIC) of the respondents or Self-Declaration in this regard does not apply in cases of this study or written work.

Research involving Plants
The author(s) solemnly declare(s) that this research has not involved the plants for experiment and field studies. Some contexts of plants are also indirectly covered through literature review. Thus, during this research the author(s) obeyed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

Research Involving Local Community Participants (Non-Indigenous) or Children
The author(s) solemnly declare(s) that this research has/have directly involved local community participants or respondents belonging to non-Indigenous peoples. However, this study has not involved any child in any form directly. The contexts of different humans, people, populations, men/women/children and ethnic people were only indirectly covered through literature review. Therefore, a prior informed consent (PIC) of the respondents or Self-Declaration in this regard applies in case of this study.

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
The author(s) has/have NOT complied with PRISMA standards to an extent.

Competing Interests/Conflict of Interest
Author(s) has/have no competing financial, professional, or personal interests from other parties or in publishing this manuscript. There is no conflict of interest with the publisher or the editorial team or the reviewers.

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The authors used an artificial intelligence (AI) language model (ChatGPT, developed by OpenAI) only for grammar checking, clarity improvement, and reference formatting in APA 7th edition style. The research design, data collection, analysis, and interpretation were done entirely by the authors. The authors take full responsibility for the content of this article.

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To see original copy of these declarations signed by Corresponding/First Author (on behalf of other co-authors too), please download associated zip folder [Declarations] from the published Abstract page accessible through and linked with the DOI: https://doi.org/10.33002/nr2581.6853.080313.

INFORMATION AND CONSENT FORM FROM RESPONDENTS
(Non-Indigenous Respondents)
This form was translated into the local language for the respondents

Title of the Research: Socio-Economic Conditions of Households Around Nag-Aso Lake, Philippines: Implications for Sustainable Resource Management

Principal Researchers: Ryan Villareas Dio
School of Graduate Studies, Sorsogon State University, Sorsogon City, Philippines
Joey Richard Villarias Dio
College of Business and Management, Sorsogon State University, Sorsogon City, Philippines

Research Supervisor: Not Applicable

A) INFORMATION TO PARTICIPANTS

1. Objectives of the research
The objectives of this study were to describe the demographic and economic characteristics of households surrounding Nag-Aso Lake and to compare resource users and non-users to generate evidence that can support sustainable resource management and local development planning.

2. Participation in research
The researcher will ask you several pertinent questions. This interview will be recorded in written form and should last about 50-60 minutes. The location and timing of the interview will be determined by you, depending on your availability and convenience.

3. Risks and disadvantages
There is no particular risk involved in this project. You may, however, refuse to answer any question at any time or even terminate the interview.

4. Advantages and benefits
You will receive intangible benefits even if you refuse to answer some questions or decide to terminate the interview. You will also contribute to a better understanding of the socio-economic conditions of geothermal lake communities and may help inform policies and programs for sustainable development.

5. Confidentiality
Personal information you give us will be kept confidential. No information identifying you in any way will be published. In addition, each participant in the research will be assigned a code, and only the researcher will know their identity.

6. Right of withdrawal

Your participation in this project is entirely voluntary, and you can withdraw from the research at any time with simple verbal notice and without having to justify your decision, without consequence to you. If you decide to opt out of the research, please contact the researcher at the telephone number or email listed below. At your request, all information concerning you can also be destroyed. However, after the outbreak of the publishing process, it is impossible to destroy the analyses and results on the data collected.

B) CONSENT

Declaration of the participant

- ⇨ I understand that I can take some time to think before agreeing or not to participate in the research.
- ⇨ I can ask the research team questions and ask for satisfactory answers.
- ⇨ I understand that by participating in this research project, I do not relinquish any of my rights, including my right to terminate the interview at any time.
- ⇨ I have read this information and consent form and agree to participate in the research project.
- ⇨ I agree that the interviews be recorded in written form by the researcher: Yes ( ) No ( )

Signature of the participant: _____ Date: _____

Surname: _____ First name : _____

Researcher engagement

I explained to the participant the conditions for participation in the research project. I answered the best of my knowledge the questions asked and I made sure of the participant's understanding. I, along with the research team, agree to abide by what was agreed to in this information and consent form.

Signature of the researcher : Date : 31-10-2024

Surname: Dio First name: Joey Richard

- ⇨ Should you have any questions regarding this study, or to withdraw from the research, please contact Mr. Joey Richard Villarias Dio by e-mail jvdio@sorsu.edu.ph
- ⇨ If you have any concerns about your rights or about the responsibilities of researchers concerning your participation in this project, you can contact the Sorsogon State University, Sorsogon City, Philippines, by email op@sorsu.edu.ph